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‘Expedicion al Interior de la Republica del Peru.’ Por Juan G. Nystrom. Donor, the author. ‘Reise durch Nord Afrika, von Tripoli nach Kuka.’ By Gerhard Rohlfs. Donor, Dr. A. Petermann. Memoir of the Hydrographical Department of the Admiralty, 1868. Donor, Captain G. H. Richards, R.N., Hydrographer. ‘La Terre.’ Par Elisée Reclus. 2 vols. 1869. Purchased. ‘Ueber Compas und Compas-Karten.’ Von Dr. Sophus Ruge. Dresden, 1869. Donor, the author. ‘On Greenland Algæ.’ By Professor Dickie. 1869. Donor, R. Brown, Esq. ‘Pinnipedia frequenting the Spitzbergen and Greenland Seas.’ By R. Brown. 1869. Donor, the author.

ACCESSION TO THE MAP-ROOM SINCE THE LAST MEETING OF JANUARY 11TH, 1869.—Map of Vancouver Island and British Columbia. By R. Brown, Esq., F.R.G.S. Presented by A. Petermann.

The following papers were read:—

1.—*On the Effects of Forest Destruction in Coorg.* By
GEORGE BIDIE, Esq., M.D.

[EXTRACTS.]

COORG lies near the centre of the Western Ghâts, and chiefly on the eastern aspect of the range. On its western margin the crests of the chain rise up in bold peaked mountain masses, some of which attain the height of 5000 feet above the sea, and to the east of these the country consists of a series of low, long-backed hills, with intersecting deep-set valleys, running out towards, and gradually subsiding in, the table-land of Mysore. The province is chiefly drained by the Cauvery and its tributaries, but several large streams descending to the western coast of the Peninsula also have their origin in it. The Cauvery rises far to the west, and for the first 10 miles or so of its course passes down the centre of a broad, flat-bottomed valley, surrounded on three of its sides by steep lofty hills. Contrary to what might have been expected, this large basin contains but little forest, so that the heavy rainfall that descends on it must at once be precipitated into the river. The average elevation of Coorg is about 3000 feet above the sea, and at no distant date nearly the whole province appears to have been covered with forest. Towards the west, the remaining forest is, as a rule, dense and lofty; but at the distance of 10 miles from the crest of the ghâts it begins to get less so, and at 12 miles we enter the bamboo district, in which the trees are smaller and the jungle more open. The nature of the forest, and also the kinds of trees found in it form pretty accurate indexes of the amount of rainfall. Thus in the

dense jungle-tract, the annual fall varies from 120 to 150 inches, while in the bamboo district it ranges from 60 to 100 inches.

The rain in Coorg may be said to be derived entirely from the south-west monsoon—the showers at other seasons being few and light—and is chiefly deposited between the 1st of June and the end of September. During that period the heated plains of Central Asia cause a steady indraught of the south-east trade winds, rendered westerly by the diurnal rotation of the earth, and as these pass over an immense expanse of ocean ere they reach the land, they become heavily charged with moisture in their course. Shortly after quitting the sea, they encounter the western ghâts, standing right across their track, and drop upon them and the low country to the west of them, the greater portion of their watery freight. The chief cause of the precipitation is the reduction of temperature produced by the warm moist air coming in contact with the colder hills, and by the decrease in density that ensues as the current rolls up the mountain side. It will thus be seen that the rainfall in Coorg depends entirely on its geographical position and geological conformation. In other words, it is so located that it is traversed by the south-west monsoon at the time when that wind is most densely charged with moisture, and so elevated as to obstruct its current and cause copious precipitation. Under such circumstances, it can be of little consequence, as regards the rainfall, whether the mountain slopes are bare or clothed with dense forests, as neither condition could have any appreciable influence on the amount of precipitation; or on the course or duration of the monsoon. I look, therefore, on the forests that grow on these highlands as a consequence, and not the cause, of the rain; and this view is supported by the change that takes place in the nature of the forest as we proceed eastward from the crests of the ghâts and the rainfall diminishes—the gradual diminution being easily accounted for on purely physical grounds. It does not appear, therefore, that the annual rainfall in Coorg has or can be sensibly diminished by the destruction of forests which has taken place.* At the same time it must be stated that the natives of the district complain that of late years their country has become hotter and drier from want of rain, and that rice crops have been diminished or lost from a failure of water in streams that used to run throughout the year. These changes they attribute to the cutting down of forests on coffee estates; and it will, therefore, be necessary, to inquire, what

* It would have been well if this view could have been supported by records of the actual rainfall during the last 15 or 20 years, but, unfortunately, prior to the beginning of 1863, no reliable observations appear to have been made. At present there are gauges at three stations, watched by careful observers.

effects the destruction of forests actually may have had on the climate and streams of the country. In so far as regards the rainfall, the subject has been already discussed, so that it only remains to notice its bearing on other elements of climate and on the drainage.

It is only since the advent of the European planter, or during the last twelve years, that felling of forests to any considerable extent has taken place in Coorg, and as the clearing has progressed in annual instalments of comparatively small extent, the results have crept on gradually, so as to render them much less obvious than if the entire extent had been cleared in a single season. There can be no doubt, too, that the evil influences called forth by forest destruction do not attain their full force immediately, but go on increasing from year to year until they acquire a most disastrous power. The total area of land denuded of forest in Coorg to make way for coffee amounts to about 20,000 acres,* and the clearings have been mostly made in the dense jungle tract, although a good many estates have of late years been opened out in the bamboo district. The spots that have been selected as sites for estates are chiefly situated on the flanks and crests of low hills, the sides and bottoms of ravines, and the slopes of passes running down on the western side of the ghâts of the low country. Such localities, as a rule, are densely wooded, and, being well supplied with springs, give rise to numerous small streams. In fact, they may be looked upon as the fountains of the river-system of the country. The question then arises—to what extent are springs and streams in such situations dependent on the forest for their supply of water, and what will be the effect on them of its removal? It is, perhaps, hardly necessary to say that springs and small streams are fed by the water stored up in the earth during the rainy season. As the rain descends on natural forest, it is conveyed in various directions by the leaves towards the ground, and on reaching this prevented from running rapidly off by the dense undergrowth of shrubs and herbaceous plants, and a carpet of dead leaves. Below this it encounters a layer of vegetable mould, which, having a great affinity for moisture, absorbs it like a sponge. As soon as the humus is fully saturated, it passes on what water may subsequently fall to the subjacent mineral earth, and this process of percolation is in various ways aided by roots, which descend to great depths, perforating the densest subsoil, and even forming passages in rock. The quantity of water thus transferred to the depths of the earth and the reservoir of springs is enormous; and when the dry season

* This represents the total acreage according to returns from individual planters.

arrives, the forest again plays an important part by husbanding and giving off gradually the subterranean supplies. The means by which these beneficial influences are exerted are various and interesting. As the water rises to the surface, it is, as in the case of its descent, again partially retarded by the layer of humus, and having passed through that, so obstructed by various mechanical obstacles, that it does not readily acquire the volume of a stream, and so pass quickly away. The way in which the soil is matted together by roots in forests also renders it very difficult for a small stream to cut out a channel, and when such has been formed, it is in general so tortuous, and the current so slow, that it must lose a considerable amount of water by percolation. At the same time, the shade of forest greatly restrains evaporation, and although the quantity of water taken up and exhaled by trees is very great, a portion of it is returned as dew or fog, and what is wafted away is fully compensated for by other advantages resulting from the presence of forest. The influence of shade in modifying evaporation is well illustrated by what happens in the coffee districts after the April showers which herald the advent of the south-west monsoon. On an estate freely exposed, a day or two of sunshine after a heavy fall will have rendered the soil quite dry and hard again, whereas on an estate under forest shade the ground will continue damp for a week or more. Although their insignificance might lead to their being overlooked, there can be no doubt that the mosses, lichens, and succulent herbaceous plants, which abound in tropical forests, are also of considerable benefit in retaining moisture, as, during rain, they absorb water like a sponge, and part with it again very slowly. It would, therefore, appear that there are numerous agents and conditions in natural forests favourable to the production and permanence of springs and streams, which are not to be found in open ground originally so, or denuded of its trees by man. During the whole of my tour in Coorg and Mysore, I have endeavoured to collect information bearing on this important question; and the facts thus elicited on the whole go to prove that tropical forest is the *alma mater* of springs and streams. Various instances have been brought to my notice of springs and small streams having become quite dry since the forest was cleared away in their neighbourhood, while in numerous cases those that used to be perennial only contain water now during and for a short period after the monsoon. Similar results have been found to follow the destruction of forests growing near the sources of streams in all parts of the world.

When land is being cleared for coffee culture, the woods and

their undergrowth are cut down and burned, and, during the conflagration, not only is the ground deprived of its carpet of vegetation, but a portion of the humus consumed, and the remainder so dried that it is liable to be washed away. When rain falls on such ground, instead of being delayed and gradually conveyed into the soil, it at once rushes down the bare slopes, enters the nearest nullah, and is rapidly carried out of the district. At the same time, a certain portion of the surface soil is carried away, the conservative agencies of the forest being no longer in existence. The effects of this degrading process continued through a number of years may be well seen on the crests and slopes of some of the lower hills in Coorg, in what is called grass or *banay* land. In such situations nothing is left but the barren stony subsoil covered by a coarse grass, or bearing a few stunted shrubs of some hardy description. The most striking results of clearing, however, are the channels cut out in new situations by the storm-water as it seeks a lower level, and the landslips caused by percolation behind banks of earth, which have no longer the binding influence of tree-roots to keep them in position. The *nullahs*, too, or natural watercourses, which used to be sufficient to carry off the surplus water, are no longer so, and an impetuous torrent dashes down them, eroding their banks and carrying along with it not only earth, but stones often of considerable size. These results were very forcibly pointed out by Major Sankey in his Report on the Public Works in Coorg for the official year 1865-6, in which he shows that great damage has of late years been done to roads and bridges in the province by the floods resulting from forest clearance. This Report drew the attention of the Right Hon. the Secretary of State for India to the subject, and in July 1866 he forwarded a despatch to the Government of India, which induced them to suggest to the Madras Government the necessity for a further inquiry into the effects of these freshets, and thereupon they requested the opinion of Dr. Cleghorn, the Conservator of Forests, on the subject. Accordingly, in August 1867, when the monsoon was in full force, he proceeded to examine the Cauvery, which, as already stated, drains the greater portion of Coorg. The point of observation was the junction of the Cauvery and Bhowani rivers, but no trace of unusual flood could be detected there, and Dr. Cleghorn also states in his Report on the subject, that the Water Returns for 20 years from the Tanjore District, which is irrigated by the Cauvery, do not show any material alteration in volume. Dr. Cleghorn's most interesting Report was published in 'Proceedings of Madras Government, Revenue Department,' dated 23rd September, 1867, and, since the commencement of this inquiry, it has been

repeatedly brought to my notice as being opposed to Major Sankey's views, and the theory in general of floods in rivers being a result of destruction of forest. A brief explanation, however, will, I think, show that Dr. Cleghorn's observations do not in the slightest degree affect the question at issue. Before the Cauvery reaches the place where it was watched by him, it receives numerous tributaries from other districts, which swell it to such a size as would render any increase of water from Coorg hardly appreciable, and it is also between Coorg and Coimbatore frequently tapped by irrigation canals, which have a considerable modifying influence on the volume of rivers. It is also worthy of notice that the forest immediately on the banks of the Cauvery, while it runs in Coorg, remains almost intact, and that the drainage of a large extent of the cleared land does not flow into it, but is carried off by streams running to the western coast of the peninsula. The effects, therefore, of forest destruction in Coorg as regards floods, would be chiefly local, and most apparent in the very spots where they were noticed by Major Sankey, viz., along the course of tributaries of the Cauvery and of other streams arising in, or passing through, denuded tracts of land. At the same time, there can be no doubt that, if the clearing is greatly extended, its effects will ultimately become apparent in rivers far beyond the limits of the province.

It now remains to offer some remarks regarding the amount and locality of tracts of forest that should be preserved to save the climate from further deterioration, regulate the drainage, and maintain the famed fertility of Coorg. Running a line from Mercara in the north by Moornaad, and due south until it touches the crest of the ghâts, we have to the west of this a large and well-defined basin, in which the Cauvery and some of its tributaries arise. Only a very few clearings have been made in this tract, and the land, as a rule, is in the hands of the Coorgs, who seem anxious that the standing forest, of which there is a great deal, should be left untouched, and the district kept sacred to them and their descendants. One can sympathise with them in these wishes; and for other substantial reasons, I would strongly recommend that forest destruction should be strictly prohibited in this quarter. Again, from the ford on the Cauvery at Moornaad down to Fraserpett, it seems desirable that a belt of jungle, at least 50 yards wide, should be kept intact on each bank of the river. Forest on the crests or slopes of hills in which important streams arise should also be carefully preserved, and the banks of streams should always, to the distance of 20 or 30 yards on each side, be left under wood, as its presence serves to keep up the water-supply in the dry season.

and to prevent floods in the rains. Although of less importance, too, there seems no doubt that trees on the banks of streams to a certain extent encourage the increase of fish. As a rule, forests growing on the eastern or western slopes of the immediate crests of the ghâts should also be preserved, as precipitation is greatest in such situations and denudation sure to cause floods, and induce in a marked degree other bad effects. The slopes of hills having a south-west exposure should also be kept under forest, as they are comparatively worthless for the culture of coffee or any other plant, the south-west monsoon destroying everything directly exposed to its force. Any one who has not been on the ghâts during the monsoon can hardly form an idea of its violence: not only is coffee injured or killed by the wind, but in exposed situations young plants newly put down have been swept away by the torrents of water running down the bare hill-sides. The importance of belts of jungle being maintained along the sides of public roads, so as to prevent landslips, &c., having already been recognised by Government, does not require any further notice here. Before giving off land in future for clearing, it would be well to submit it to a careful inspection, so as to ascertain whether any portions of it would be unfit for the growth of the plant which it is proposed to cultivate, and the forests on unsuitable parts should then be kept standing. One would think that self-interest would prevent landowners from trying to cultivate such spots, but many proofs to the contrary might be brought forward. At the same time, it could be seen whether the proposed clearing would be likely to produce floods that might prove dangerous to public works, and action taken accordingly. The rice-lands in Coorg are very peculiar, being long, narrow, winding patches, surrounded by low forest-clad hills, from which they derive their water-supply. It would manifestly, therefore, be imprudent to cut down any forest in their neighbourhood. Forest in the upper end of ravines should also be preserved, as it invariably gives birth to springs and streams.

The Paper will be published entire, in the 'Journal,' vol. xxxix.

The PRESIDENT, in expressing the thanks of the Society to Dr. Bidie, said it was highly gratifying to Geographers to see the various branches of Natural History combined, as they were in this Paper, in illustration of a great subject in physical geography. The subject also suggested matter for reflection on the part of the English nation, owing to the vast quantity of water which is lost annually, by not having proper means of accumulation, so that in time of drought our rural population have difficulty in obtaining supplies of water. A vast proportion of water ran off to the sea by the rivers, and a great part was drained off by the improved agricultural drainage. This subject had been discussed on a previous occasion, when Mr. Markham read a Paper on Southern India. In Russia he could testify himself that the practice of cutting

down great forests was, to a great extent, ruining a large portion of the country ; the water was not husbanded in the manner which had been described by the author of the Paper. The water ran off rapidly by the Volga and other great rivers, which were much lowered in summer, to the great detriment of the agriculture and commerce of the country. He hoped Dr. Cleghorn, the Conservator of Forests in India, who was present, and to whom we were more indebted than to any other gentleman in reference to this important question, would make some observations upon the Paper.

Dr. CLEGHORN said that during the last twenty years he had four or five times traversed the region alluded to in the Paper. Any one acquainted with Dr. Bidie, the Secretary of the Agri-Horticultural Society of Madras, would feel sure that he would give a careful and well-digested report upon the subject. The facts in the report dwelt mainly upon two considerations, which he thought should be discussed separately—the question of rainfall and the question of drainage. With regard to the progress of deforesting, it appeared that at the present moment about sixty Europeans went out annually as coffee-planters to the Western Ghats. The average acreage was perhaps 150 acres of forest, and the average amount of capital introduced by each planter was about 1500*l.* Therefore, there was a large amount of capital invested in that chain of Ghats. According to Dr. Bidie's report, and according to the admission of the planters themselves, 20,000 acres had been cleared in Coorg. He did not himself believe that the clearing of 20,000 acres would affect the precipitation of moisture in that vast chain of Ghats, considering its peculiar position with regard to the sea. He quite agreed with Dr. Bidie upon that point. The question of drainage was an entirely different one, and very serious consequences were stated to have ensued. These were first brought to the notice of Government in 1866, by two distinguished engineers—Colonel Lawford and Major Sankey. Major Sankey sent in a report with some remarkable artistic illustrations, showing that the water was finding a lower level ; that some of the ancient Ghats had suffered very much from the drainage ; that the old channels were found insufficient ; that the embankments were undermined and had given way on the outer side towards the sea in various places ; and that considerable damage had followed. Colonel Lawford, on the other hand, said that Coorg was becoming a great garden, at the expense of the rice provinces below, which were likely to suffer very much. The Madras Government, in 1867, directed him (Dr. Cleghorn) to proceed up the Cauvery and to examine the effect upon the river-bed. About midway, where the Bhowany joins the Cauvery, he examined the rocks on both sides where it was narrow, and he did not find any marked alteration. He insisted very strongly as to the importance of keeping up the meteorological register at Mercara, on the one hand, and on the other of keeping up the water-measurement at Tanjore. At the beginning of the south-west monsoon, more water flowed off than formerly, and the flow failed a little sooner ; there was a tendency in that direction, but it was not then so marked as to warrant any interference with the clearings to any great extent. Certain remedies were proposed, such as the preservation of all wooded crests, 800 feet from the top, on the south-west slopes where the burst of the monsoon was most violent ; also the preservation of 50 yards of wood on each side of the trunk-roads and the rivers. He concurred with what Mr. Markham stated in his paper, that on the eastern slopes it was of the greatest consequence to preserve the forests, because the mass of the population is on that side. The native population were almost universally of opinion that the climate was drier on account of these changes which man was gradually introducing. There were some interesting facts stated in Dr. Bidie's report, such as the increase of insects and insectivorous birds, the increase of certain plants, and other remarkable facts which were well worthy of attention. What was required was that the Forest officers and the Canal officers should

cordially co-operate and watch the changes from month to month. The Forest Department was a new one, initiated only 12 to 13 years ago; it was gradually increasing in usefulness, and it was receiving that great attention which it deserved. There could not well be a more momentous subject for the consideration of that Department than the one then under discussion.

Mr. GEORGE CAMPBELL could not pretend to give any opinion upon the purely scientific question as to how far the actual rainfall was affected by the clearing of forests. He entirely concurred in the view that the clearance of land had the effect of making the soil drier, of inducing a more rapid drainage by causing the flow of water in the rivers to be more sudden and rapid, the floods to be greater, and the droughts to be more severely felt. But he did not go as far as Dr. Bidie in considering that the destruction of forests was in every respect prejudicial. Dr. Bidie seemed to consider it injurious to human life. In India the contrary was the fact. Where forests were cleared away and drained the country became more healthy. He could not think that Coorg could be an exception to the rule. But then came this question,—that, as the effect of clearances was to render the soil drier and the streams more rapid, what could be done? He would not prevent coffee-planting for the sake of more moisture. The major consideration must prevail over the minor. Although we might apprehend certain bad effects indirectly, still we could not put a stop to the progress of British enterprise and the progress of cultivation. The true remedy was that which had been suggested by the President, namely, better modes of storing water for use in the dry season. The great minds of India and Europe had been turned to the subject. It had been his duty to examine some of the greatest schemes which the world had ever seen, with the view to that object,—those which Sir Arthur Cotton had suggested with respect to the waters of the Godavery. It was proposed to run enormous dams across great valleys, and thus store the flood-waters, and, at the same time, do what was done on a smaller scale in France,—protect the country below from inundation. At present these schemes had scarcely reached beyond the point of theory. The Government of India were most anxious to do all they could to promote them. When he was chief Commissioner in the Central provinces, the Government sent him engineers from Madras skilled in these matters, and he had directed them to survey the upper branches of the Godavery in the hope that one day Sir Arthur Cotton's scheme would be carried out. With respect to the preservation of forests the Government were not behind, and of late years they had been most zealously active. The whole country was covered with forest officers, who were doing all they could towards the preservation of forests in India, short of stopping cultivation.

Mr. CLEMENTS R. MARKHAM entirely concurred with Dr. Cleghorn and Mr. Campbell. It appeared to him when he was in India that, looking to the large number of people going out there, and the quantity of capital that was being invested; it would be hopeless to attempt to prevent the destruction of forests on a large scale. But what the Government might do was to prevent the forest being destroyed in places where the land cleared would be useless for cultivation. He remembered seeing in more than one place—in one place on a very large scale—on the north face of the great hills near Coorg, an enormous area cleared of forest, which, after it had been cleared at considerable cost, was found to be absolutely useless for coffee cultivation, owing to the rocky nature of the soil. Now that forest might have been preserved by the Government. It ought not to have been sold. The peaks of the hills could always be preserved. He did not doubt that the slopes of the hills would be eventually covered with cinchona and coffee plantations, and that the climate would ultimately deteriorate in those districts. But he did not see why there should be any danger to the plains from floods, because though the forests might be destroyed, still in certain positions on the hills

enormous reservoirs might be formed, which would have the same effect as the forests in preventing the sudden rush of surface drainage, which was the great danger to be apprehended to the lower country where rice was cultivated.

2. *Description of the Island of Rapa.* By Captain VINE HALL.

I MAY commence my notes by saying that the island has been hitherto erroneously called Opara; but on my recent visit to it I enquired particularly as to its proper native name, which I found was pronounced nearly as if spelt with an L, and two ps, or Lappa. Opara, they said, "was English name." In future it will be called Rapa.

This Island—like other places one might mention—has acquired a temporary and adventitious value, principally from its position, and the possession of a harbour. It was first discovered by the English navigator Vancouver, since which time it has apparently been very little visited except by the small trading-vessels from the neighbouring islands. Vancouver described it truly, as rugged, formed of craggy mountains, with very little level ground—the narrow valleys between the precipitous hill-sides affording the only space for a limited cultivation.

The position of Rapa is in $27\frac{1}{2}$ ° s. latitude, and 144° w. longitude; about 700 miles s.e. of the Society group, and as nearly as possible two-thirds of the distance between Panama and Wellington.

Very little was generally known about the island till lately, and nothing of its being favoured with so perfect a harbour. The finding of it out was the result of very many enquiries I made from every one I could hear of who had been to the South Sea Islands, as to the existence of some suitable spot, where we might have a coal dépôt. For, on the establishment of the Panama service, I was so impressed with the desirability, if not necessity, of some stopping-place near the route, that I used every effort for months, endeavouring to find one. At last I was rewarded for my pains by hearing of Rapa.

Its situation, just on the outer verge of the Southern Archipelago and in the direct track (not the direct line) between Panama and New Zealand makes it particularly advantageous as a place of call in case of accident or deficiency of fuel.

And, speaking of the track of the steamers between New Zealand and Panama, I will for an instant advert to the difference of route in going towards Panama and returning from it.

Leaving Wellington, we adopt what is called the "great circle" course, which, though apparently roundabout, is in reality the